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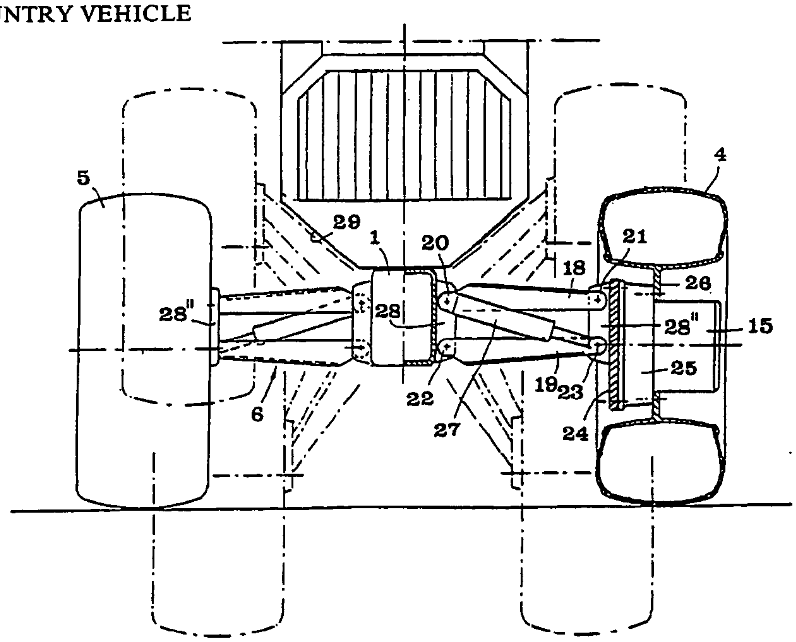


(57) Abstract

A cross-country vehicle comprises a chassis or frame (1) supported by at least two pairs of wheels (4, 5) and itself supporting a driver's cab and an engine, at least one pair of cooperating wheels (4, 5) being mounted on movable wheel suspensions (6) allowing raising and lowering each separate wheel relative to the chassis (1). Each wheel suspension (6) comprises two separate, substantially parallel arms (18, 19) each of which is pivotally connected at opposite ends by means of articulations (20, 21; 22, 23), on the one hand to the chassis and on the other hand to a mounting plate (24) on which the wheel (4, 5) is rotatably mounted, and a double-acting hydraulic cylinder (27) extending diagonally between an inner articulation (20) of one parallel arm (18) and an outer articulation (23) of the other parallel arm (19), the wheel being raisable and lowerable by a relative change of the length of the hydraulic cylinder (27) in relation to the length of said arms (18, 19).

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# CROSS-COUNTRY VEHICLE

## Technical field of the invention

This invention relates to a cross-country vehicle comprising a chassis or frame supported by at least two pairs of wheels and itself supporting a driver's cab and an engine or a power source, at least one pair of cooperating wheels being mounted on movable wheel suspensions which allow raising and lowering each individual wheel relative to the chassis and each comprise two separate, substantially parallel arms each of which is pivotally connected at opposite ends by means of articulations, on the one hand to the frame and on the other hand to a mounting plate or a part on which the wheel is rotatably mounted.

## State of the art

A vehicle of the type described above is previously known from US Patent Specification 4,186,815. In this prior art vehicle construction, the wheels are however movable by means of single-acting, telescopic cylinders which are disposed between an outer articulation for the upper parallel arm and a supporting frame in the area of the driver's cab. This means that the cylinders concerned are capable only of holding the wheel pressed against the ground and of following the unevennesses therein, whereas not of actively lifting each individual wheel, e.g. for facilitating maintenance thereof. Further, said telescopic cylinders are placed in highly exposed positions where there is a substantial risk of damage due to buckling and impacts, and of premature wear.

## Brief account of the inventive concept

The present invention aims at overcoming the above-mentioned drawbacks inherent in the prior art vehicle by providing a vehicle which is able to advance smoothly also on very difficult terrain with

a minimal risk of damage to and wear of the wheel suspensions. According to the distinctive features of the invention, these and other objects are achieved in that there is provided diagonally between an inner articulation of one parallel arm and an outer articulation of the other parallel arm a double-acting hydraulic cylinder which by changing its stroke length brings about lowering and raising of a separate wheel relative to the vehicle frame.

Since the hydraulic cylinders are double-acting and disposed diagonally between the two parallel arms, several advantages are gained. Thus, the cylinders are efficiently protected both against mechanical damage from buckling and impacts and against wear. Since the cylinders are double-acting, the wheels are capable of moving over obstacles at high speed since active hydraulic pressure is used for acting on both the upward and the downward movement of the wheels. Further, the required stroke length of the cylinders becomes minimal, resulting in low piston speeds, low generation of heat, small frictional losses, minimal wear, excellent obstacle-taking properties and small risks of damage to the piston rod by buckling. Further, by individual control function the double-acting cylinders can lift separate wheels off the ground, e.g. in connection with maintenance, changing of wheels, mounting of anti-skid equipment etc. Finally, it should be pointed out that the position of the cylinders does not necessitate an increase of the vehicle width.

## Brief description of the accompanying drawings

In the drawings,

FIG. 1 is a partly transparent perspective view of the inventive vehicle in the form of a harvester when operating in a forest;

FIG. 2 is a perspective view showing only the vehicle chassis with the associated wheels and wheel suspensions;

FIG. 3 is a side view of the vehicle;

FIG. 4 is a schematic top plan view of the vehicle;

FIG. 5 is an end view of the vehicle as seen from the rear, i.e. from the left in Fig. 3,

FIG. 6 is an enlarged end view showing only the rear wheels of the vehicle;

FIG. 7 is a diagram illustrating a hydraulic system included in the vehicle for automatically adjusting the vertical position of the wheels;

FIG. 8 is an enlarged section of levelling means included in the hydraulic system according to Fig. 7;

FIG. 9 illustrates different conditions where the vehicle can be used; and

FIG. 10 is a diagram illustrating different possible angles of inclination or slope of the ground on which the vehicle can operate.

Detailed description of a preferred embodiment of the invention

Figs. 1 and 2 illustrate a cross-country vehicle which is designed in accordance with the invention and, in this example, is a harvester. The harvester comprises in conventional manner a chassis or frame generally designated 1 and supported by wheels, in this case four wheels 2, 3, 4, 5, which are mounted on a corresponding number of substantially identical wheel suspensions generally designated 6. The chassis 1 itself carries a driver's cab generally designated 7, a power source 8 which in practice advantageously is a diesel engine, and a hood or box 9 which can be used for housing parts of the electric or hydraulic system of the vehicle. In this case, a crane generally designated 10 is also mounted on the driver's cab 7.

In the illustrated embodiment, the chassis or frame 1 is divided into two parts 11, 12 interconnected by a vertical hinge pin 13 which in a manner known per se allows articulated frame steering of the vehicle.

The two frame parts 11, 12 are pivoted relative to each other by means of two hydraulic cylinders 14, 14'. In the following description, the frame parts 11 and 12 are referred to as front and rear frame parts, respectively, and the wheels 2, 3 are hence referred to as front wheels and the wheels 4, 5 as rear wheels. As appears from the above, the driver's cab 7 and the hood 9 are disposed at the front and the engine 8 at the rear of the vehicle. In this context, it should however be noted that the wheels 2-5 are hydrostatically driven by means of hub motors 15 adapted to rotate the wheels identically in one direction of rotation, whereby the vehicle can be run equally conveniently backwards and forwards.

In Fig. 2, there is shown a gear wheel 16 for driving a gear rim 17 (see Fig. 1) on which the driver's cab 7 is mounted. By means of this gear rim, the driver's cab can be rotated through 360° to any desired angular position relative to the front frame part 11.

In practice, the two frame parts 11, 12 may advantageously consist of hollow sections, e.g. sectional elements of rectangular cross-section, which wholly or partly accommodate liquid tanks. For instance, the rear frame part 12 may house a fuel tank supplying the engine 8 while the front frame part accommodates a hydraulic oil tank supplying the hydraulic system of the vehicle (to be described in more detail later on).

Reference is now also made to Figs. 3-6. As best appears from Fig. 6, each wheel suspension 6, e.g. the suspension of the wheel 4, comprises two separate, substantially parallel arms 18, 19 each of which is pivotally connected at opposite ends by articulations 20, 21 and 22, 23, respectively, to the vehicle frame and to a mounting plate or member 24 on which the hub motor or hydraulic motor 15 is fixed, a rim 26

for the wheel 4 being bolted to the rotatable periphery 25 of the motor. Between the two parallel arms 18, 19 extends a third arm 27, more specifically diagonally between an inner articulation 20 of the parallel arm 18 and an outer articulation 23 of the other parallel arm 19. The third arm 23 is in the form of a double-acting hydaulic cylinder which, by changing its length, lowers or raises the wheel 4 relative to the vehicle frame. More specifically, extension of the effective length of the cylinder 27 means that the wheel 4 will be lowered, while shortening of the cylinder length means that the wheel will be raised relative to the vehicle frame. In practice, the two parallel arms 18, 19 may advantageously consist of rigid, suitably relatively wide plates whose length cannot be changed. As best seen in Fig. 2, the articulations 20, 22 may consist of hinge pins extending between two spaced-apart brackets 28, 28' provided on the outer side of the rear frame part 12. The outer articulations 21, 23 may also advantageously consist of such hinge pins extending between spaced-apart brackets 28" on the inner side of the mounting plate 24.

As best seen in Fig. 4, the arms of each wheel suspension 6 extend substantially at right angles to the longitudinal axis L of the frame, the above-mentioned articulations or hinge pins 20, 21, 22, 23 being directed parallel to the longitudinal axis L.

In Figs. 3 and 5, the wheels 2-5 are shown by full lines when in a normal or starting position N in which the wheel suspension arms 18, 19 extend substantially horizontally out from the frame 1. In this normal position, the wheels are maximally spaced from the central vertical plane passing through the vehicle and designated V in Fig. 5. The clearance of the frame, i.e. the distance from the underside of the frame to the ground or the underside of the wheels, may in practice be about 0.5 m. From the normal position

N, the wheels can be raised and lowered to upper and lower end positions O and U, respectively, by pivotal movement of the parallel arms 18, 19 upwards and downwards, respectively, by means of the diagonal arm or hydraulic cylinder 27. In the illustrated Example, the arms 18, 19 can be pivoted upwards through about 45° and downwards through about 60°. In the former case, the frame will be lowered towards the ground with a decrease of the ground clearance to about 0.1 m, whereas in the latter case the frame is raised to a top position in which the clearance is 0.9 m or more. During both raising and lowering, the wheels will move along arcuate, especially part-circular paths of movement and, in both cases, they will approach the vertical plane V, as illustrated by dot-dash lines in Figs. 5 and 6. If it is assumed that the vehicle, when in the normal position N, has an overall width of 2.0 m as counted from outside to outside of a pair of opposite wheels (corresponding to a ground clearance of 0.5 m), the vehicle width or track width can be reduced, by raising or lowering the wheels, to 1.8 m (position O) and 1.5 m (position U), respectively. By such a reduction of the track width, the vehicle can travel through passages which are considerably narrower than the normal, maximal track width of the vehicle. The high ground clearance is of course also advantageous for the vehicle when passing over obstacles on the ground, such as rocks and stumps, and also when running the vehicle on land with newly planted trees.

As described above, the arms 18 can be pivoted upwards through about 45° from the essentially horizontal, normal position. To allow this and also permit an advantageously low position of the engine 8 (to achieve the lowest possible centre of gravity), the underside of the engine is formed with oblique boundary surfaces 29 both of which extend from the area of the upper long side edges of the sectional frame part

12 obliquely upwards towards the vertical boundary walls of the engine. The hood or box 9 is similarly provided with oblique, lower boundary walls. The arms 18, 19 can be pivoted downwards through about 60°. In other words, the total angular displacement of the arms is about 105°. In practice, this total angular displacement should be at least 90° and advantageously is within the range of 100-110°.

As appears from Figs. 3 and 4, the steering articulation 13 is located substantially midway between the front and rear pairs of wheels 2, 3 and 4, 5, respectively. It should further be noted that the engine 8 is positioned with its centre of gravity substantially vertically above an imaginary axis between the centre of rotation of the two rear wheels 4, 5, whereby the entire weight of the engine will load the rear wheels only. In Fig. 4, it is shown by dot-dash lines how the rear part of the vehicle can be swung out no less than 50° from the central longitudinal axis L of the vehicle. In practice, such a considerable angular steering displacement in combination with the moderate wheel base gives a highly restricted inner turning radius, which of course confers substantial advantages when running the vehicle especially on land with young trees, since it then is extremely easy to steer. In positions of maximal angular steering displacement, the basic stability of the vehicle is reduced by only about 10% despite the extremely large angular displacements.

The hydraulic cylinders 27 included in the four wheel suspensions of the vehicle are connected to a communicating hydraulic system which can automatically press, for instance, the right wheel downwards when the left wheel is raised for taking an obstacle and vice versa, whereby the frame 1, with the equipment mounted thereon, can be maintained in a horizontal

or levelled position, both when taking high obstacles and when travelling on steep slopes.

The vehicle has hydrostatic power transmission to the hub motors 15 in all four wheels, more specifically from a variable hydraulic pump connected direct to the engine 8, while the crane 10 is supplied from a separate pump unit which also serves as pump for the automatic levelling system for the cylinders 27.

Reference is now made to Figs. 7 and 8 schematically illustrating the above-mentioned levelling system. The main circuit of the system is of conventional type and comprises a hydraulic pump 30 supplying hydraulic medium through a number of control valves 31, 32, 33, 34 and from there to a tank 35. In Fig. 7, the hydraulic cylinders connected to the respective wheels are designated 272, 273, 274 and 275. The system further includes three hydraulically controlled levelling means 36, 37 and 38 the first two of which serve to provide levelling laterally while the last-mentioned one provides levelling longitudinally. A first inclination-detecting sensor 39 serves to sense a commencing ground slope laterally and, in response thereto, activate the levelling function of the system, more specifically by electrically operating the control valve 32. In the case of a longitudinal slope, corresponding activation is effected by means of a second sensor 40 operating the valve 33.

Preferably, all levelling means 36, 37, 38 are identical. As appears from Fig. 8, each levelling means consists of a cylinder 41 comprising two mutually separated pistons 42, 43 which, together with the two end walls 44, 45 of the cylinder, define first and second end chambers 46 and 47, respectively, and are rigidly connected to each other by means of a rod 48 or the like extending through an opening in a partition 49 which suitably is disposed centrally in the cylinder 41 and which, together with said pis-

tons 42, 43, defines first and second intermediate chambers 50 and 51, respectively, communicating with lines 52, 53 of which the line 52 allows evacuation of hydraulic medium from the first intermediate chamber 50 by displacement of the pair of pistons 42, 43 in one direction relative to the cylinder as a result of hydraulic medium being supplied to the first end chamber 46, while the second line 53 allows supply of hydraulic medium to the then expanding second intermediate chamber 51, and vice versa.

In principle, the hydraulic system is equally designed for both pairs of wheels, but for simplicity's sake, the end marked with a directional arrow will be referred to as "front end" hereinafter.

The system operates as follows: When the ground passes from a horizontal level into a slope, for instance to the left, the vehicle frame 1 begins successively to deviate from its horizontal position. The sensor 39 then activates the valve 32 supplying hydraulic medium via the line 54 to the levelling means 36 and 37. The process then is the same for both pairs of wheels, but for simplicity's sake the hydraulic function for only the two front wheels 2, 3 will now be described. The lateral-levelling means 37 receives hydraulic medium in the chamber 46, thereby expanding, and the pistons 42, 43 interconnected by the rod 48 are pressed in the direction of the end wall 45, thus decreasing the volume of the end chamber 47 and pressing hydraulic medium through the line 55 to the valve 32 and back to the hydraulic tank 35. When the piston 42 is moved in the direction of the partition 49, oil is pressed from the first intermediate chamber 50 out through the conduit or line 52 and is conducted by the line 56 to the plus connection of the cylinder 273. Through a branch line 57, about 15% of the flow also passes to the minus connection (piston rod end) of the cylinder 272 so as to create a vacuum

there as the second intermediate chamber 51 of the levelling means 37 at the same time increases its volume and draws flow from the plus connection of the cylinder 272 and the minus connection of the cylinder 273 through the line or conduit 53. When, by the process now described, the cylinders 273 and 272 have increased and decreased, respectively, their stroke lengths, the parallel arms 18, 19 of the wheel suspensions have changed their angular positions in such a manner that the frame is again in the horizontal position, whereupon the activation by means of the sensor 39 is interrupted.

If, instead, the ground tends to slope to the right, the function now described will occur in the reverse order, which is achieved by the valve 32 supplying hydraulic medium in the opposite direction, i.e. through the line 55 instead of the line 54. Since the hydraulic systems of the front and rear wheels communicate with each other via the lines 54, 55, all four wheels can move individually on uneven terrain or over obstacles on the ground. Since the vehicle frame is torsionally rigid throughout its entire length, the front and rear wheel cylinders will cooperate continuously with four-wheel stability in all situations. If the driver wishes to act on the lateral-inclination control manually, the sensor 39 is temporarily shut off, whereupon the valve 32 can be operated by hand.

When the sensor 40 detecting longitudinal inclination records a deviation from the horizontal position, e.g. on a downward slope, it activates the valve 33 which via the line 58 actuates the levelling means 38 to supply inclination-compensating hydraulic medium to the levelling means 37. At the same time, the means 38 receives a corresponding flow from the rear levelling means 36. Concurrently with this volume flow, the means 36 and 37 automatically control the change of

volume such that hydraulic medium is supplied to the cylinders 272-275 by volumes adapted to function. This is performed by control action from the sensor 39 monitoring that the volume is distributed while maintaining the horizontal position laterally. In the case of an upward slope, the function is reversed, meaning that the valve 33 supplies a pressure flow through the line 59 instead of the line 58. In the cases where the driver wishes to act on the inclination control manually, both in the longitudinal direction and in the lateral direction, the sensors 39 and 40 are shut off, and the communicating function of the lines 54 and 55 is blocked by means of the three-way valve 60. The valve 32 then is operationally connected only to the levelling means 37 while the valve 34 now engaged is separately connected to the levelling means 36.

Since the levelling means 36, 37, 38, together with the cylinders 272-275, have a flow volume functionally adapted for automatic levelling, this volume must be increased for higher ground clearance or decreased for lower ground clearance. This is carried out manually, respectively by supplying via the control valve 31 hydraulic medium through the line 61 and by evacuating hydraulic medium by means of the counterpressure in this line.

The hydraulic cylinders 272-275 are dimensioned by a wide margin to withstand the hydraulic pressures to which they may be subjected by external loads, e.g. in connection with crane operations. The fundamental principle of the hydraulic system now described is based on the fact that the pressure, to a minor extent, builds up a functionally controlled counterpressure. This is effected in that the pressure lines of one vehicle side to the plus connection of a cylinder also branch off to the minus connection of the cylinder of the other vehicle side. It should

here be noted that the piston rods of the cylinders are dimensioned with such a large diameter that the minus end has a pressure area of only about 15% as compared with the plus side. This system entails that while the plus end provides for the bearing capacity of the vehicle, the system yields a minor power portion to the minus end of the cylinder of the other vehicle side. This arrangement should assist in pressing fluid from the plus end of the cylinder over to the expansion chamber of the levelling means, at same time as the compression chamber with high pressure presses a corresponding volume to the plus end of the other cylinder. In this way, the system will have a smooth, jerkfree and powerful motional function. When manually operated, this system also allows the driver to let the machine rest on three wheels in maximal ground clearance position and raise the fourth wheel to the level of the underside of the frame, for instance to provide access for maintenance work or to allow the vehicle to climb, e.g. onto a trailer or the like. In such a position, the wheel can be raised a maximum distance which considerably exceeds the wheel diameter.

Reference is now again made to Fig. 1 illustrating how the revolving driver's cab 7, in addition to two opposite, substantially planar side walls 62, comprises front and rear walls 63, 64 both of which have an arched or part-circular shape in cross-section to make the entire cab extremely rigid. All these walls extend from a robust floor structure mounted on the gear rim 17. One side wall 62 is provided with a door while the opposite wall is made extremely robust to be able to take up the stresses from a crane mounting in the form of a stable, horizontal hinge pin 65. The main boom of the crane is pivoted about the hinge pin 65 by means of a hydraulic cylinder 66 which is also mounted on the side wall 62. Since the crane

is mounted on the driver's cab in this manner, there is no need for separate bracket and rotational devices in that the crane is rotated relative to the vehicle chassis along with the cab itself. Since the front and rear cab walls have arched shape without any protruding corners, the space between the hood 9 and the engine 8 can be minimised without reducing the possibilities of rotating the cab. It should further be observed that the centre of rotation of the cab is located a slight distance ahead of the steering articulation 13, whereby the crane and the driver will be centrally positioned on the machine. This, in turn, means good visibility and an efficient working position for the driver.

The crane 10 is a knuckle-boom crane with an outer boom having a telescopic extension and with a main boom 68 which is substantially L-shaped in order, when placing the crane in a parking position, to locate the boom behind and below the window 69 provided in the side wall 62 of the driver's cab. The angular shape of the main boom 68 also makes it easy to mount the hydraulic cylinder 66. In the illustrated embodiment, the crane tip or the free end of the outer boom 67 is provided with a working assembly 70, such as harvesting equipment. According to a preferred embodiment, this equipment is eccentrically disposed in relation to the outer boom 67, more specifically offset to the left in relation to the arm 67, whereby the driver, when sitting in the cab 7, will always have an open view of the equipment which is not blocked by the booms 67, 68.

Fig. 9a shows the inventive vehicle from the side when in normal position N. Figs. 9b and c illustrate the vehicle when travelling on a downward and an upward slope, respectively. Fig. 9d is an end view of the vehicle when in the normal position according to Fig. 9a. Fig. 9e shows the vehicle with the chassis

maximally lowered in relation to the wheels, while Fig. 9f shows the vehicle with the chassis maximally raised with respect to the ground. Fig. 9g shows the vehicle when travelling over an obstacle, while Fig. 9h shows how the vehicle can be inclined in its entirety in that both wheels on one side of the vehicle are raised in relation to the frame while the wheels on the opposite side are lowered. It should here be pointed out in particular that the centre of gravity of the vehicle still is located within the wheel gauge despite the relatively substantial inclination of the vehicle. Fig. 9i shows the vehicle in the same inclined position, but with one of the wheels raised to a top position, the vehicle maintaining its stability although only three wheels are in contact with the ground.

Fig. 10 schematically illustrates different slope conditions under which the vehicle can operate without any risk of turning over. As appears from the diagram, the vehicle can automatically assume horizontal position on slopes up to 36% (about 20°) longitudinally and 60% (about 30°) laterally, while maintaining permanent four-wheel stability. Another advantage of the inventive vehicle is that the risk of accidents occurring when getting on and off the vehicle is reduced in that the vehicle can be lowered to a level where the cab floor is only 0.5 m above the ground. Not until the driver has installed himself in the cab is the chassis, together with the cab, again moved up to normal working height. The revolving cab facilitates the driver's work and prevents injuries of the cervical vertebrae due to wear as a result of repeated turning of the head otherwise unavoidable. The mounting of the crane to one side wall of the cab means that it will always follow the rotational movements of the cab and that the outward and inward movements of the crane arms will always take place in the sighting line of the driver. This makes him more relaxed,

thus increasing the accuracy of crane operations. In forest areas subjected to thinning where there is poor visibility because of the abundance of twigs and branches, the driver can raise or lower the cab to get an optimal sighting line between twigs and branches which are blocking the view. Since the machine can be raised to high ground clearance and be given a small overall width or be given a large and stable overall width and also has an exceptional cornering capacity, it makes a highly flexible and convenient working vehicle that can be readily adapted to many different working situations.

A specification of technical data for a working vehicle design for practical use according to the present invention is given below.

| | |
|---|---|
| Total length | 3.3 m |
| Width (infinitely variable) | 1.5-2.0 m |
| Total height (infinitely variable) | 2.3-3.1 m |
| Ground clearance (infinitely variable) | 0.1-0.9 m |
| Wheel base | 2.2 m |
| Wheel dimension (four wheels) | 400x22.5 mm |
| Total weight (including crane but excluding working implement) | 3,500 kg |
| Engine power | 45 kw (60 hp) |
| Tractive force (four hydrostatically driven hub motors) | 4,000 kp |
| Power transmission, hydrostatic | |
| Hydraulic pressure | 350 kp/cm$^2$ |
| Brakes, mechanical in hub motors | |
| Braking power | 6,400 kp |
| Speed, cross-country driving, four-wheel drive | 0-13 km/h |
| Speed, road-driving, two-wheel drive | 0-26 km/h |
| Steering principle | articulated frame steering |
| Max. steering angle | $\pm$ 50° |
| Levelling, longitudinal, automatic up to | 36% inclination |

| | |
|---|---|
| Levelling, lateral, automatic up to | 60% inclination |
| Maximum lateral inclination to turning-over limit | 120% inclication |
| Obstacle-taking height, horizontal | 0.8 m |
| Driver's cab, revovling on gear rim | 360° |
| Crane, knuckle-boom type with telescopic extension, range | 5 m |

<u>Possible modifications of the invention</u>

It goes without saying that the invention is not restricted only to the embodiment described above and illustrated in the drawings. Thus, the inventive principle is also applicable to cross-country vehicles other than forest machines. It should also be emphasised that the minimum and maximum values stated above, (0.1 and 0.9 m, respectively) for the ground clearance are not limitative. Thus, these limit values may vary both upwards and downwards according to vehicle size and requirement. For instance, it is conceivable to permit lowering the vehicle frame as far as the ground so that the frame carries the vehicle while all the wheels are raised, e.g. for mounting anti-skid equipment, servicing etc. If required, the machine may be supplemented with different implements mounted at its front end. Such implements may be e.g. clamping jaws, harvesting equipment, excavator or plough equipment and sundry loader implements.

CLAIMS

1. A cross-country vehicle comprising a chassis or frame (1) supported by at least two pairs of wheels (2, 3; 4, 5) and itself supporting a driver's cab (7) and an engine or power source (8), at least one pair of cooperating wheels being mounted on movable wheel suspensions (6) which allow raising and lowering each individual wheel relative to the chassis and each comprise two separate, substantially parallel arms (18, 19) each of which is pivotally connected at opposite ends by means of articulations (20, 21; 22, 23), on the one hand to the frame (1) and on the other hand to a mounting plate or a part (24) on which the wheel (2, 3, 4, 5) is rotatably mounted, characterised in that there is provided diagonally between an inner articulation (20) of one parallel arm (18) and an outer articulation (23) of the other parallel arm (19) a double-acting hydraulic cylinder (27) which by changing its stroke length brings about lowering and raising of the wheel relative to the frame.

2. Vehicle as claimed in claim 1, characterised in that all the wheels (2, 3, 4, 5) of the vehicle are individually connected to the frame (1) each by means of a suspension (6) comprising said double-acting hydraulic cylinder (27), whereby the frame is adjustable into a horizontal position independent of varying ground slope conditions, not only by lateral levelling, that is by raising or lowering at least one of the wheels of a cooperating pair of wheels (2, 3 and 4, 5, respectively), but also by longitudinal levelling, that is by raising or lowering one or both of the wheels of a front pair of wheels (2, 3) in relation to the wheels of a rear pair of wheels (4, 5).

3. Vehicle as claimed in claim 1 or 2, c h a r a c t e r i s e d in that four hydraulic cylinders (272, 273, 274, 275) each forming diagonal arms of variable length in four wheel suspensions (6), namely for a pair of front wheels (2, 3) and a pair of rear wheels (4, 5), are included in a hydraulic system which, in addition to a pump (30) and a tank (35), comprises three levelling means (36, 37, 38), more specifically a longitudinal-levelling means (38) and two lateral-levelling means (36, 37) for the two pairs of wheels, first and second inclination-detecting sensors (39, 40) for sensing the ground slope laterally and longitudinally, and control valves (32, 33) which are activable by said sensors and one (33) of which is activable by one of said inclination-detecting sensors (40) and connected to the longitudinal-levelling means (38) which upon supply of hydraulic medium brings about supply of hydraulic medium from the front lateral-levelling means (37) to the rear lateral-levelling means (36) or vice versa, while raising the front wheels concurrently with a lowering of the rear wheels or vice versa, and the other of which is activable by the second lateral-inclination detecting sensor (39) and connected to the two lateral-levelling means (36, 37) each of which, upon supply of hydraulic medium from the control valve (32), brings about supply of hydraulic medium to the plus chamber of one of the two hydraulic cylinders (272, 273) of a pair of front and rear wheel suspensions, respectively, while lowering the associated wheel relative to the frame concurrently as hydraulic medium is evacuated from the minus chamber of the second cylinder while raising the associated wheel, thus levelling or maintaining the frame in a horizontal position.

4. Vehicle as claimed in claim 3, c h a r a c t e r i s e d in that each levelling means consists of a cylinder (41) comprising two separate pistons

(42, 43) which, together with the end walls (44, 45) of the cylinder, define first and second end chambers (46, 47) and which are rigidly interconnected by means of a rod or the like extending through an opening in a partition (49) suitably centrally disposed in the cylinder (41) and defining, together with said pistons (42, 43), first and second intermediate chambers (50, 51) communicating with lines (52, 53) one of which permits evacuating hydraulic medium from the first intermediate chamber (50) by displacement of the pair of pistons in one direction relative to the cylinder as a result of hydraulic medium being supplied to the first end chamber while the second line permits supplying hydraulic medium to the then expanding second intermediate chamber (51), and vice versa.

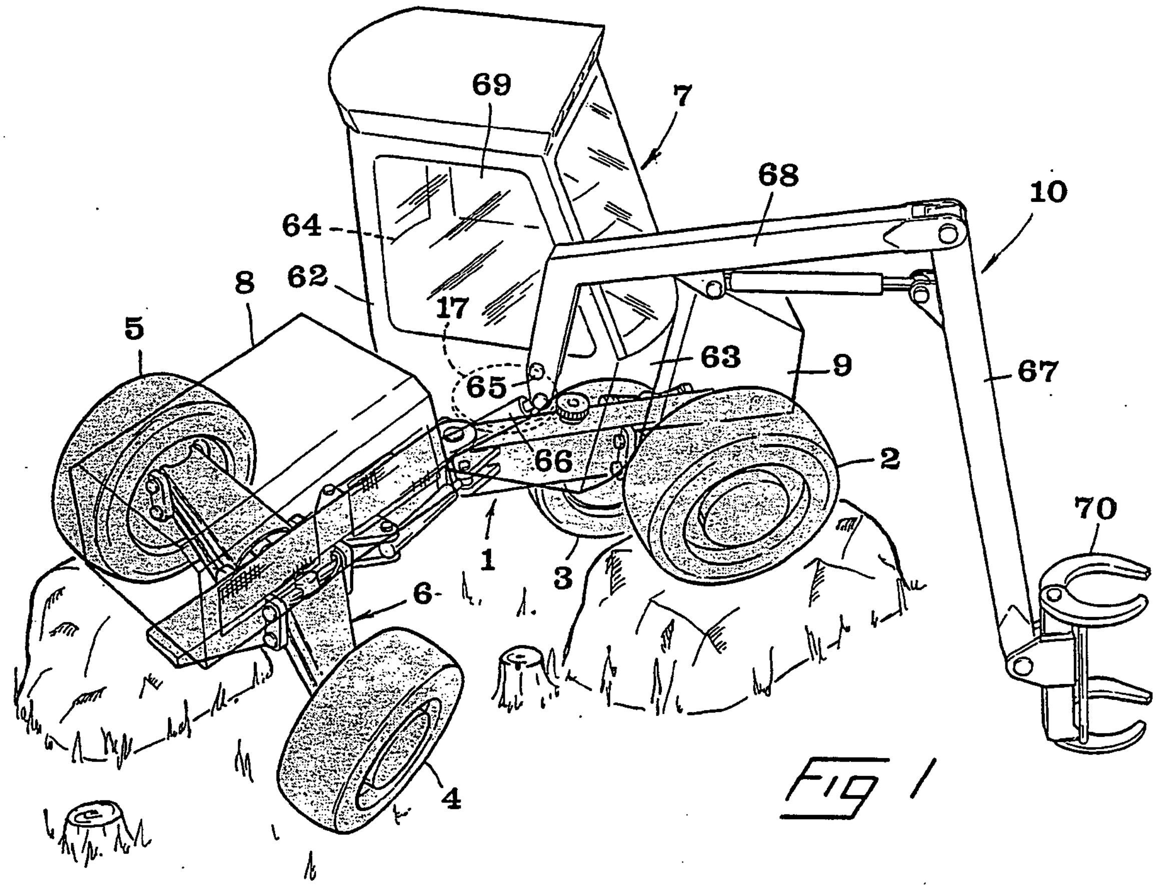
69
7
68
10
64
62
8
17
5
65
63
9
67
66
2
70
1
3
6
4

Fig 1

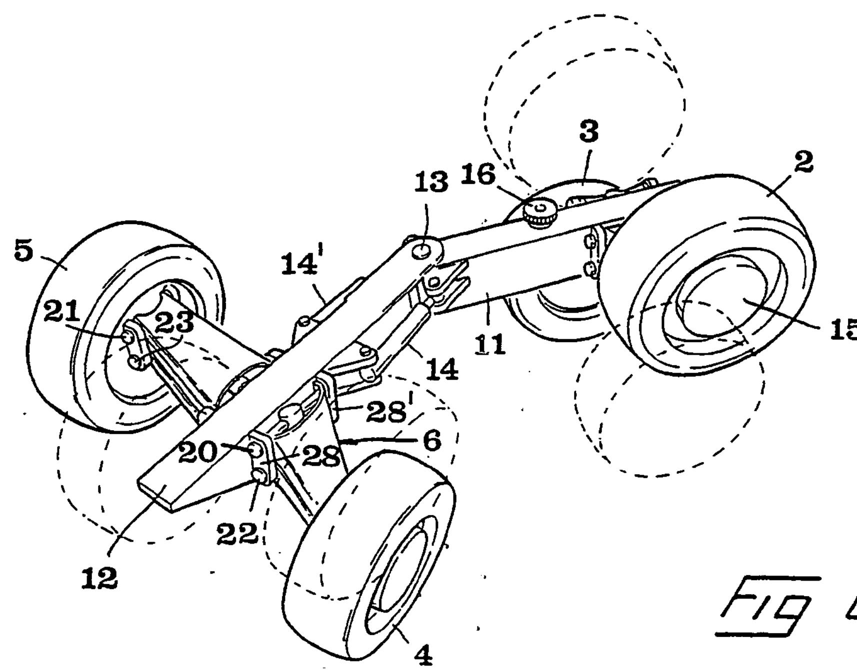
3
2
13
16
5
14'
21
23
11
15
14
28'
20
28
6
22
12
4

Fig 2

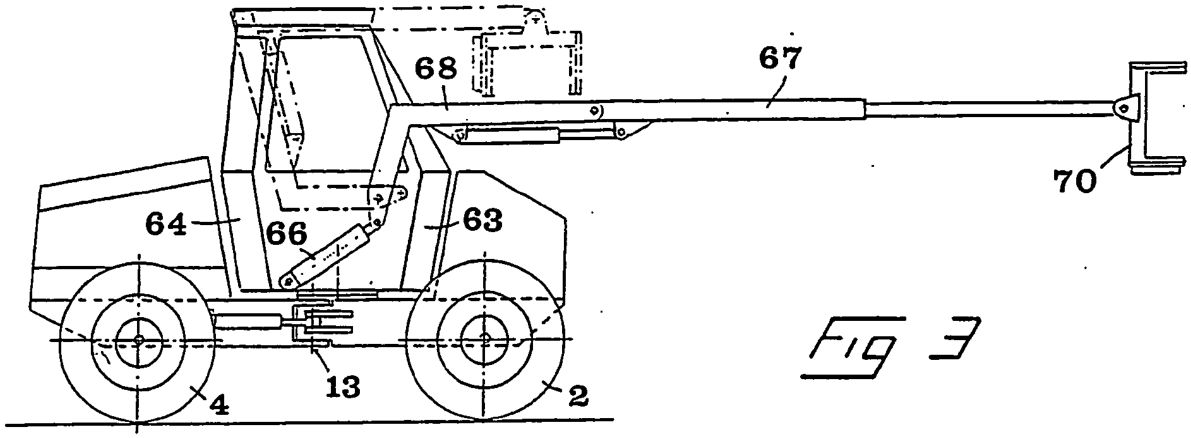


Fig 3

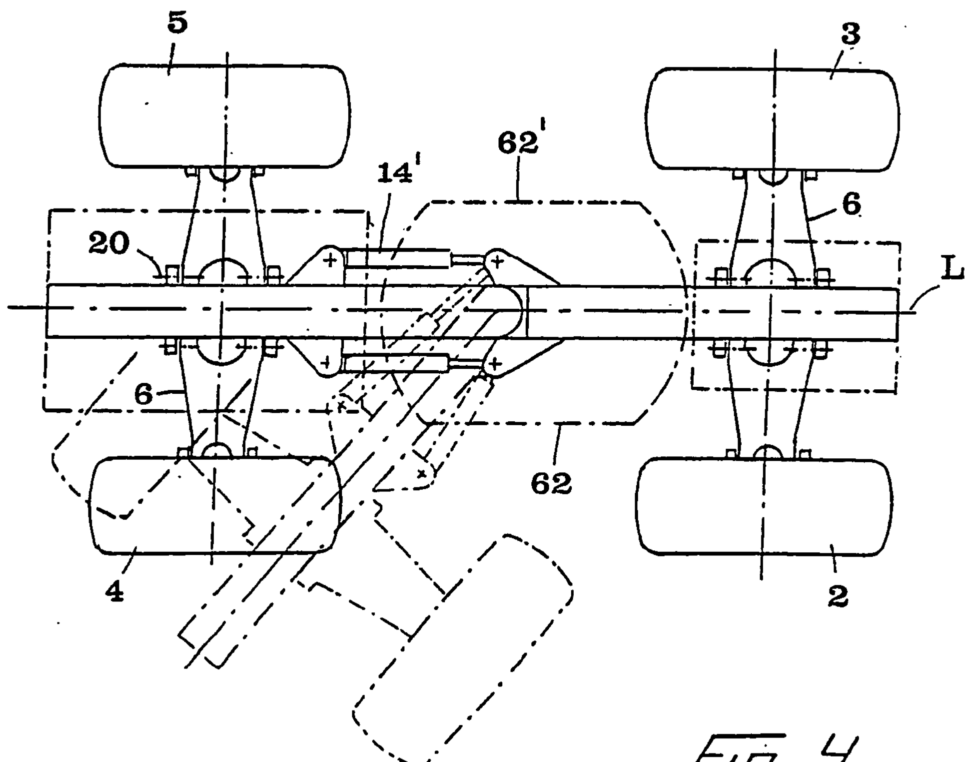


Fig 4

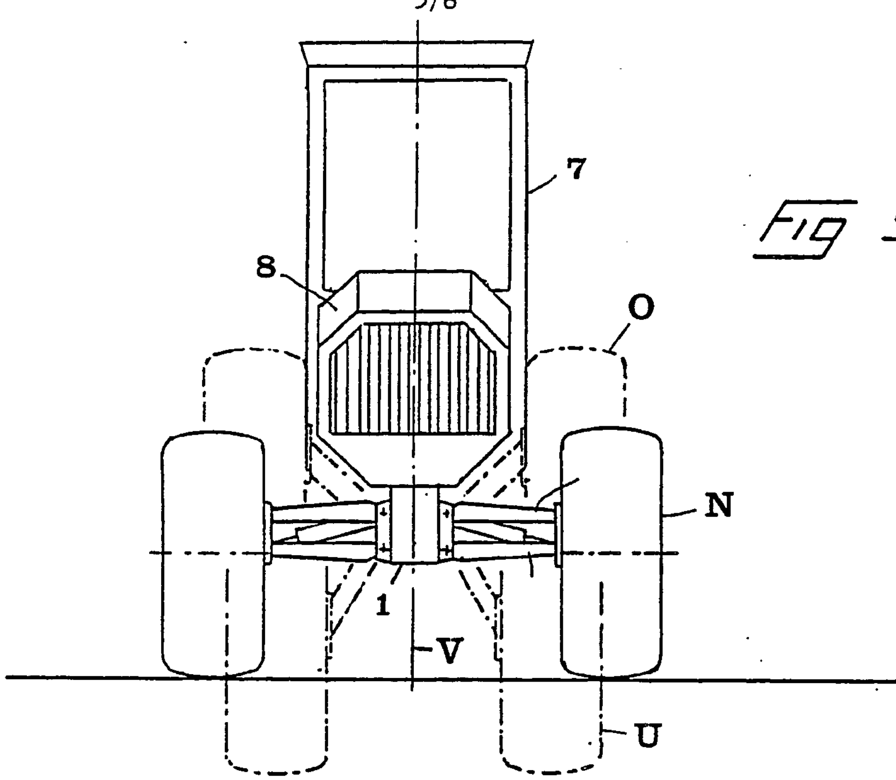


Fig 5

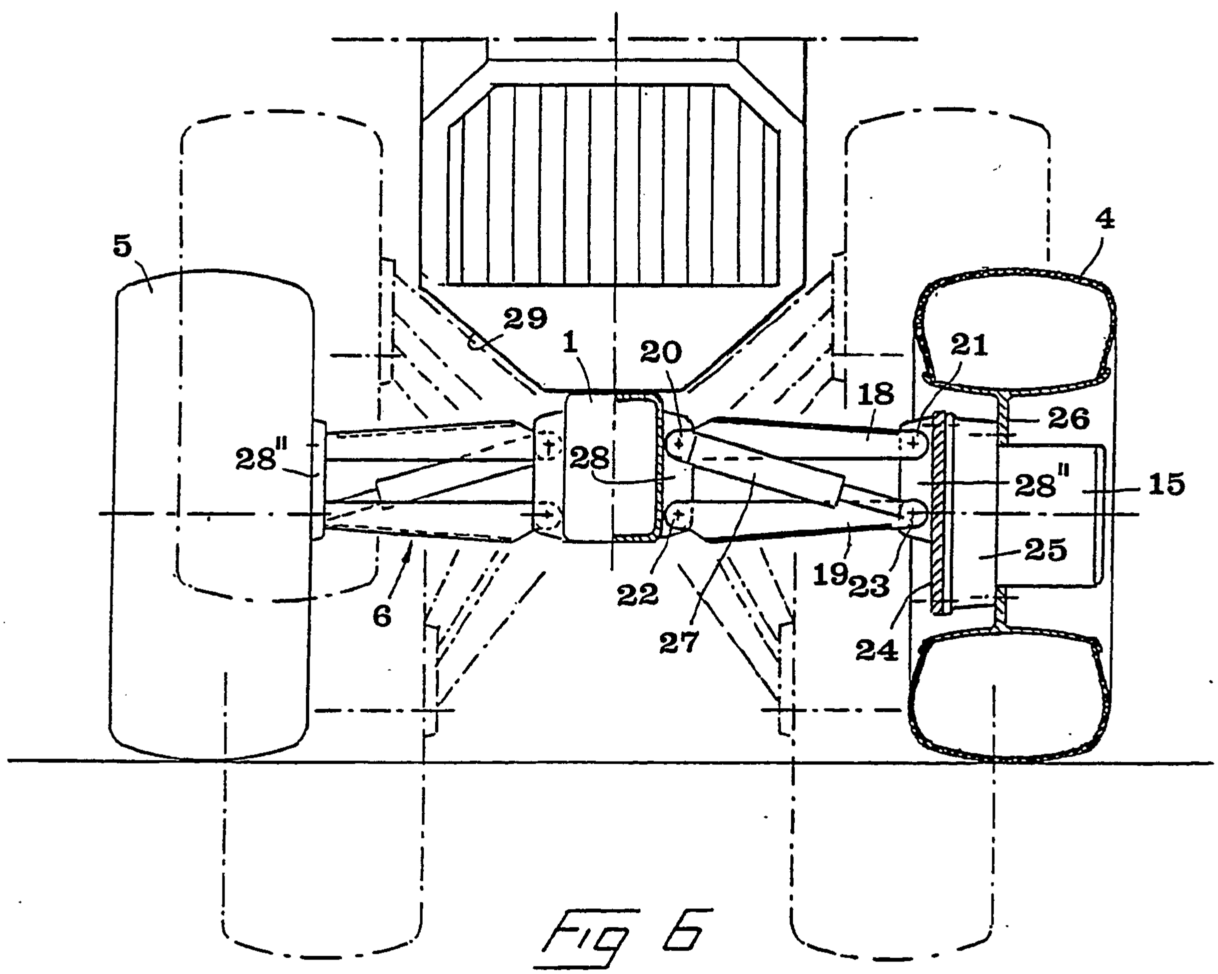


Fig 6

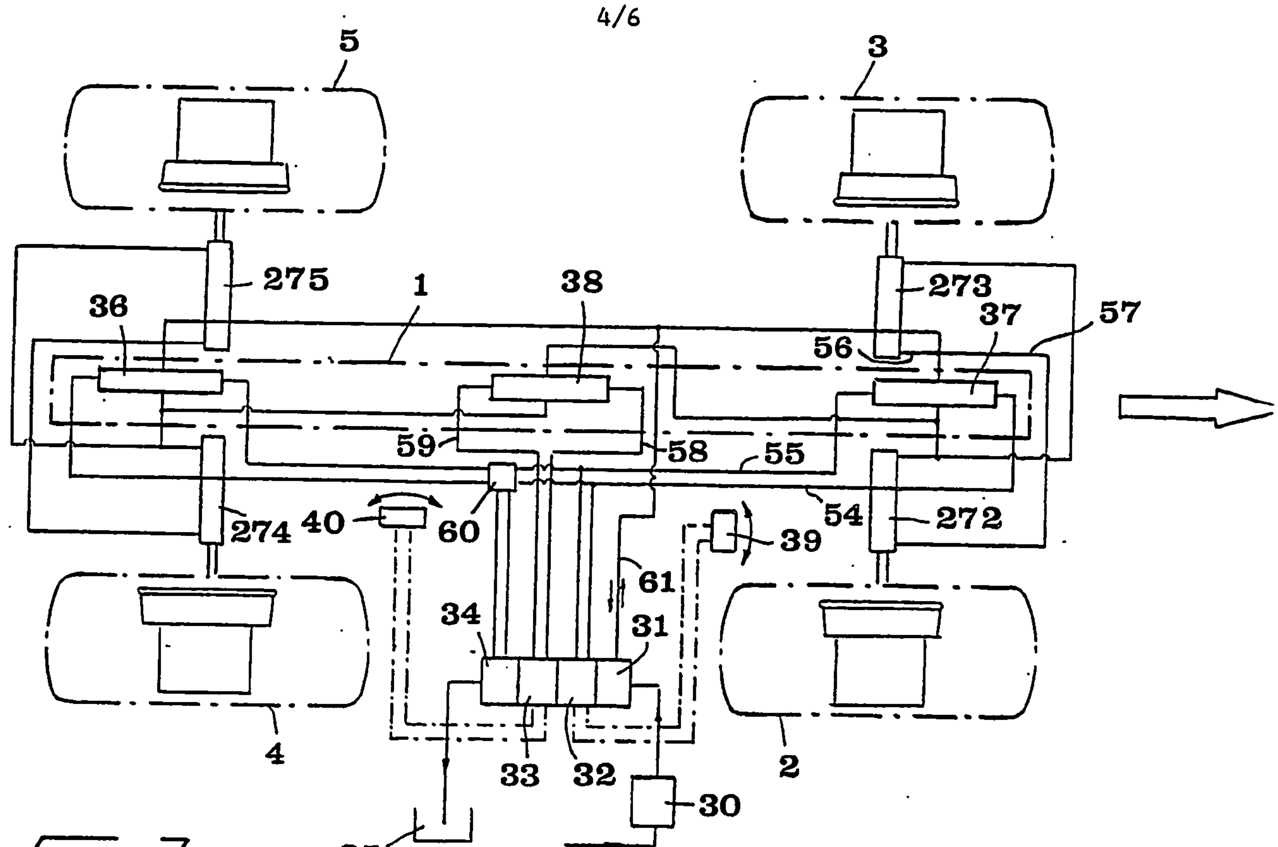
5
3
275
1
38
273
36
37
57
56
59
58
55
54
40
60
274
39
272
61
34
31
4
33
32
2
30
35

Fig 7

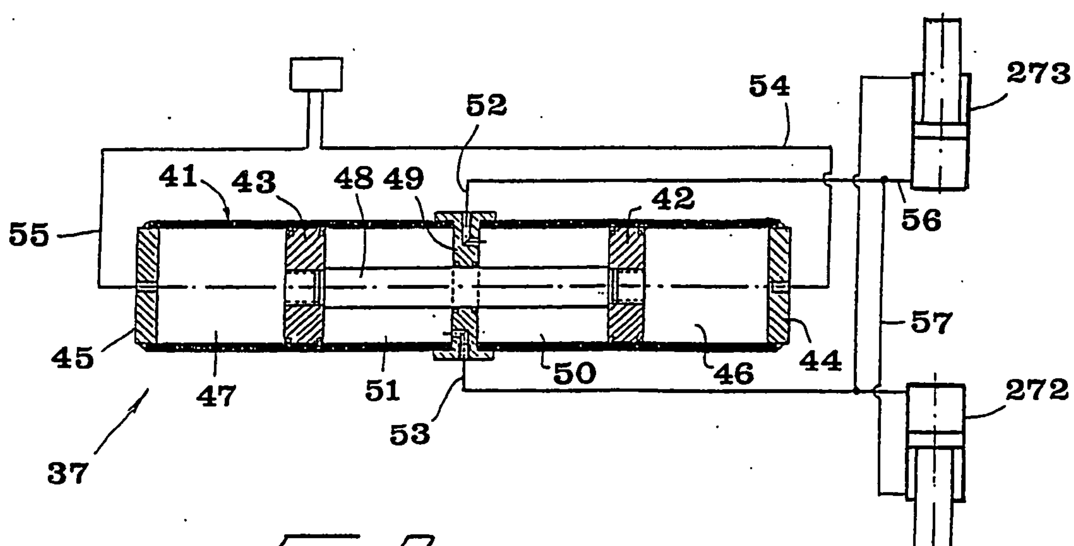
52
54
273
41
43
48
49
42
56
55
57
45
44
47
51
50
46
53
272
37

Fig 8

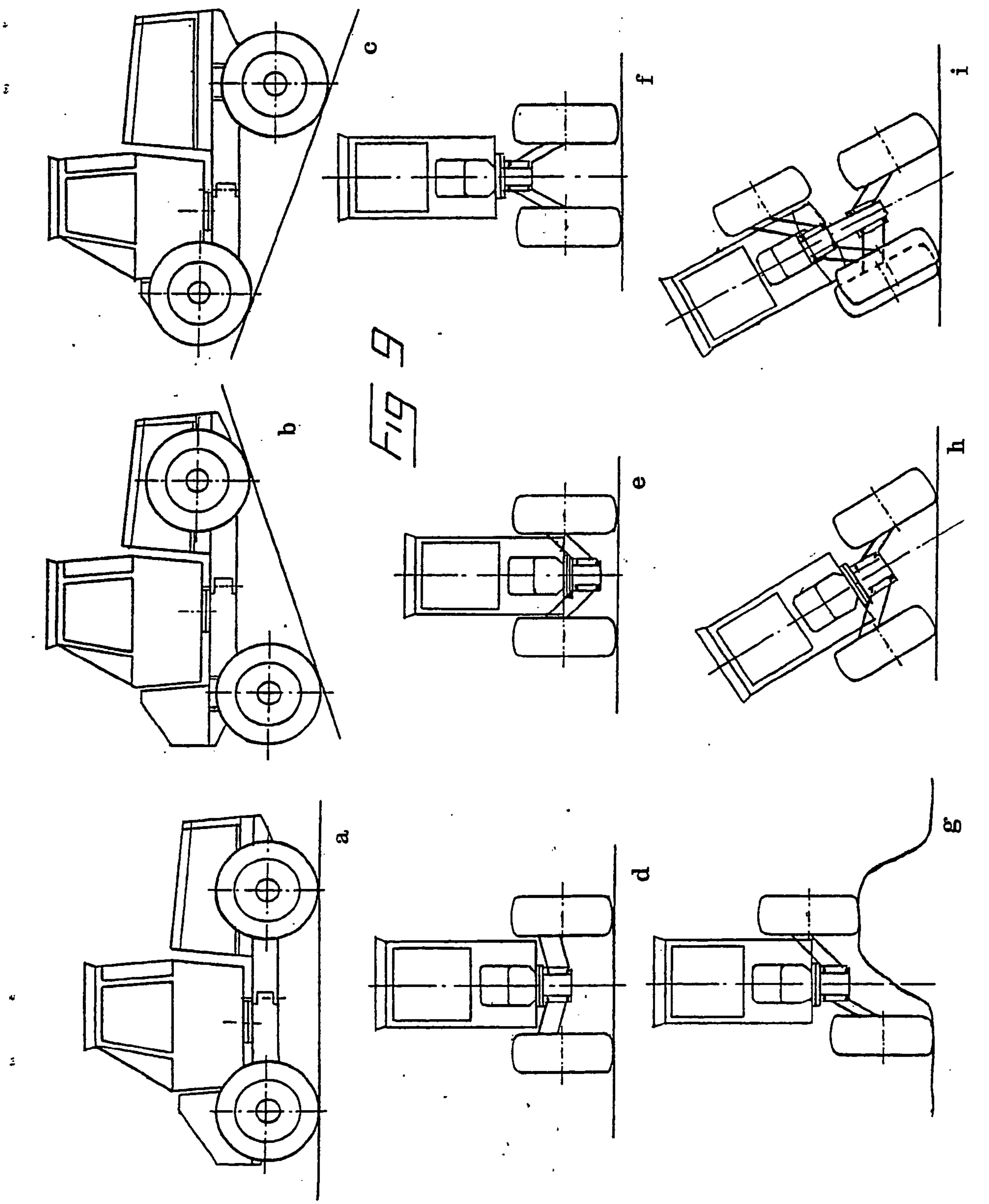


Fig 9

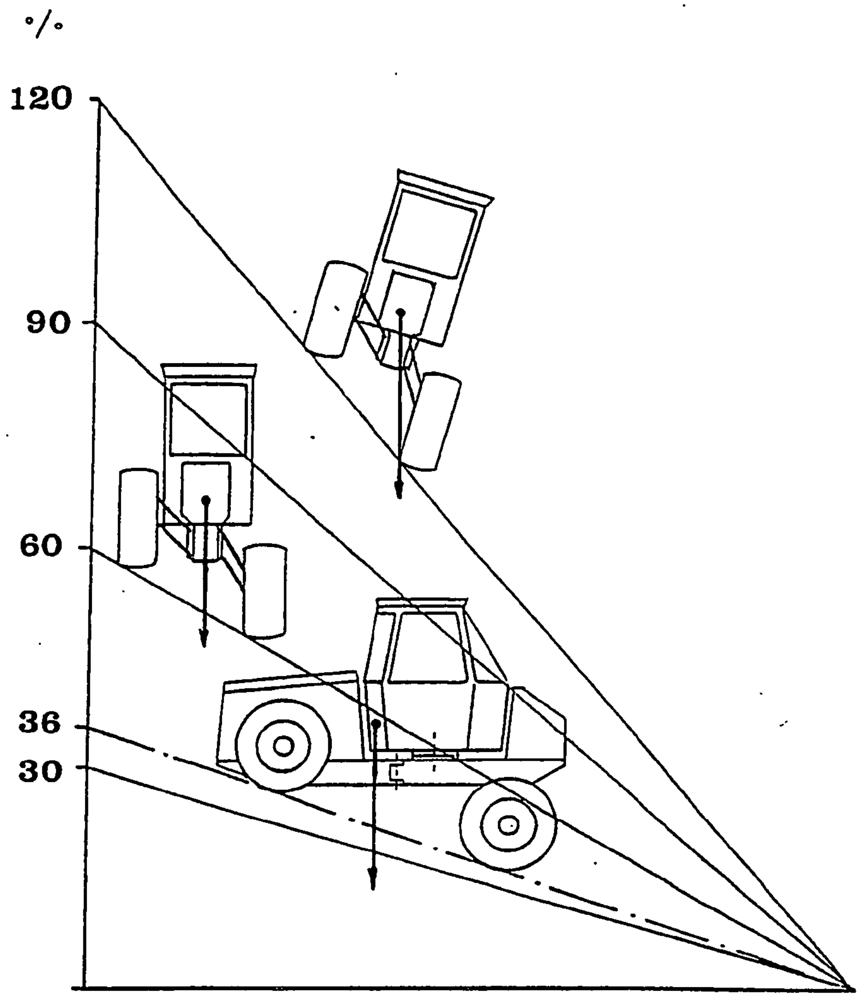


Fig 10

# INTERNATIONAL SEARCH REPORT

International Application No PCT/SE88/00384

**I. CLASSIFICATION OF SUBJECT MATTER** (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC 4

B 60 G 17/00, B 62 D 49/08

**II. FIELDS SEARCHED**

Minimum Documentation Searched[7]

| Classification System | Classification Symbols |
|---|---|
| IPC 4 | B 60 G 3/18-/26, 17/00; B 62 D 49/00, /08, 61/00, /10 |
| US Cl | 180:22,23,24,41; 280:6,6.1,6.11,704,705,709 |

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

SE, NO, DK, FI classes as above

**III. DOCUMENTS CONSIDERED TO BE RELEVANT**[9]

| Category[*] | Citation of Document,[11] with indication, where appropriate, of the relevant passages[12] | Relevant to Claim No.[13] |
|---|---|---|
| A | FR,A, 2 112 830(LANGEN & CO) 23 June 1972 | |
| A | US,A, 2 901 051(J L THIBODEAU) 25 August 1959 | |
| A | US,A, 4 186 815(HART) 5 February 1980 | |
| A | FR,A, 1 430 354(M AUGUSTIN DELAPORTE) 20 January 1965 | |

* Special categories of cited documents:[10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

**IV. CERTIFICATION**

| Date of the Actual Completion of the International Search | Date of Mailing of this International Search Report |
|---|---|
| 1988-10-24 | 1988 -11- 15 |
| **International Searching Authority** | **Signature of Authorized Officer** |
| Swedish Patent Office | Kenneth Gustafsson |

Form PCT/ISA/210 (second sheet) (January 1985)